

FINAL REPORT ON PROJECT #NCC5-402 NASA EPSCoR

NASA-EPSCoR PREPARATORY GRANT PROJECT ENTITLED:

**“CONTINUING DEVELOPMENT OF A COLLABORATIVE PLAN TO
FURTHER ENGAGE SOUTH DAKOTA IN NASA’S EARTH SCIENCE
ENTERPRISE”**

PROJECT PERIOD:

July 1, 1999-December 31, 2001

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Roadmap of Successful Planning Activities and Related Accomplishments

An ongoing set of research planning activities have occurred in South Dakota as a consequence of the past two years of NASA-EPSCoR Preparation Grants. During this time a group of approximately 60 scientists, engineers, and university administrators in South Dakota have been directly involved as "theme team" members in a series of five all-day meetings to identify the research and technological priorities that are consistent both with NASA-ESE's interests and the State's expertise. Institutions represented within the group's membership include: South Dakota School of Mines & Technology, South Dakota State University, Augustana College, University of South Dakota, USGS EROS Data Center, Si Tanka College, Sinte Gleska University, Sisseton Wahpeton Community College, USGS Water Resources Division, US National Weather Service, and the SD Department of Environment & Natural Resources. Many of these organizations are also members and affiliates of the SD Space Grant Consortium. Additional information about the "theme team" members and the planning meetings is available at [<http://www.sdsmt.edu/space/nasaepscor/>](http://www.sdsmt.edu/space/nasaepscor/).

The evolving plan has been guided by the following desirable actions:

- To establish new contacts and strengthen existing linkages with NASA Centers, relevant NASA researchers, and key personnel at the USGS EROS Data Center.
- To promote participation from the State's major research institutions, State agencies, and relevant businesses in South Dakota that are interested in strengthening our scientific and technological enterprises.
- To develop the State's scientific talent and infrastructure for enhanced competitiveness in research, development, and technology-based economic development.
- To encourage greater participation by under represented groups, especially Native Americans, in scientific education and research.
- To build greater public and political support in South Dakota for the overall science, engineering, and technology enterprise.
- To communicate the benefits of current and future NASA programs to the progress and development of South Dakota, the Northern Great Plains Region, and the Nation.

The success of this comprehensive effort over the past two years is evidenced by one very significant result. That is, individuals located and employed at different institutions within South Dakota have now assembled themselves into a functioning "team" with shared visions for the development of earth science-based research. This "team" has agreed to pursue a research strategy that is centered on: a) the establishment of quantitative links between geospatial information technologies and fundamental climatic and ecosystem processes in the Northern Great Plains (NGP), and b) the development and use of coupled modeling tools, which can be initialized by data from a combined satellite and surface observational network, to provide reliable predictions and management guidance for hydrologic, agricultural, and ecological systems of the NGP. Whereas this "team" of earth scientists includes experimentalists, modelers, and theorists,

they are all attracted by the lure of the earth science fieldwork that comprises a part of each of the three proposed research projects.

Another measure of achievement is the number of linkages the "team" members have made with external partners, including NASA personnel, during the last two years.

Summary of Trips/Linkages between SD Researchers and NASA Personnel

The SD NASA EPSCoR Program acknowledges the importance of building and maintaining effective linkages with NASA collaborators. This is to help assure that input and output is provided at both the state and federal level and that the development of NASA EPSCoR research infrastructure within South Dakota is in areas of strategic importance to NASA's mission. We believe that our proposals, our Technical Advisory Committee, and the agencies and organizations that are contributing matching dollars, demonstrate partnerships and cooperative arrangements that are well distributed throughout the State.

This section summarizes twenty-three (23) trips made by SD researchers to form collaborative linkages with NASA personnel during the two-year SD NASA EPSCoR Preparation Grant period. The reader is referred to the following website for additional information on these trips including dates, locations, personnel and institutions involved, and meeting details <<http://www.sdsmt.edu/space/nasaepscor/trips.htm>>. Table 1 represents a general overview of some of the linkages, followed by a summary of significant interactions that developed.

Table 1: Significant Collaborative Trips (SD Researchers and NASA Personnel)

Travel Date	SD Personnel	NASA Center/Activity/Contact
Oct. 2000	Alan Bender, SDSU	Dr. Stuart Gage, Director of CEVL, MSU
Oct. 2000	Kevin Dalsted and others, SDSU	JPL - Drs. Yunjin Kim, Mahta Moghaddam, Paul Siqueira, Paul Rosen, and Jeff Hilland
July 2000	John Helsdon, SDSM&T	Dr. Steve Goodman of GHCC at MSFC
June 2000	Pat Kozak, SDSM&T	Travel to Niobrara Valley Preserve. Worked with EROS & NASA personnel on calibration of Landsat 7 overpasses.
May 2000	Tom Durkin and Dr. Sherry Farwell, SDSM&T	Upper Great Plains SATS Symposium
May 2000	Dr. Dan Swets, Augustana	EPSCoR Expo at JSC
April 2000	Dr. Daniel Swets and Catherine Van Note, Augustana College	Council on Undergraduate Research "Posters on the Hill" session. Meeting with SD Congressional delegation.
April 2000	Dr. E. Duke & P. Kozak, SDSM&T	USGS Spectroscopy Laboratory
Mar. 2000	SDSU's Kevin Dalsted	SAR Users Working Group (SUWG) Meeting in Washington, D.C. area.

Feb. 2000	SDSM&T's Dr. Ed Duke, Pat Kozak, Dr. Maribeth Price and Dr. Lee Vierling, and SDSU's Dr. S. Burckhard	AVIRIS Earth Science and Applications Workshop at NASA's JPL
Feb. 2000	Mary O'Neill and Michelle Kelly, SDSU	Stennis Space Flight Center meeting with UAO and contractor InDyne, Inc.
Feb. 2000	Dr. Bradley Reed, EROS Data Center	Dr. Reed visited with Dr. Jim Tucker, NASA-Goddard.
Jan. 2000	Drs. D. Helder, S. Burckhard, V. Schaefer, D. Clay and S. Schiller, and S. Shin, and M. Kelly, SDSU	Goddard Space Flight Center
Jan. 2000	K. Dalsted & others, SDSU	NASA staffers and perhaps JPL scientists
Dec. 1999	Dr. Sharon Clay and Chuck Cole, SDSU	Pecora 14 LandSatellite Information III Demonstrating the Value of Satellite Imagery conference in Denver
Nov. 1999	SDSU's Kevin Dalsted, Mary O'Neill, and Dr. David Clay SDSM&T's Drs. Pat Zimmerman and Lee Vierling	UMAC-PARC Workshop "Climate Change: Meeting the Challenge/Seizing the Opportunities" Grand Forks, ND
Nov. 1999	Michelle Kelly, NASA EPSCoR grad. Student, SDSU	Remote Sensing Applications Conference and Workshop, Auburn, AL, and meeting/tour at MSFC.
Nov. 1999	Dr. Bill Capehart, SDSM&T	1) Land Surface Hydrology Program Investigators Meeting, Columbia, MD 2) Visit to GSFC
Dec. 1999	Dr. Andy Detwiler, SDSM&T	1) Visited "Center for Interdisciplinary Remotely-Piloted Vehicle Studies" (CIRPAS) with NASA's Tony Strawa 2) Visited NASA Ames
Nov. 1999	Dr. Bradley Reed, EROS Data Center	Dr. Bradley Reed met with Dr. Compton "Jim" Tucker from NASA Goddard
Sept. 1999	Dr. Maribeth Price and Dr. Lee Vierling, SDSM&T	GSFC Space Day
Aug. 1999	Dr. Dan Swets, Augustana College, Dr. Bradley Reed and Jim Rowland from EDC	Established working relationship with Dr. Jim Tucker at Goddard

Summary of Significant Interactions

SDSU's State Climatologist Dr. Alan Bender visited Dr. Stuart Gage of MSU in October 2000. The meeting was productive in discussing MSU's Signature Program in Land Use and Land Cover Change, which promotes cross-disciplinary projects that will be built around a systems approach to the study of changes in land use systems.

SDSU's October 2000 visit to JPL was successful in bringing SDSU's Dr. Vernon Schaefer, Dr. Sung Shin, Dr. Suzette Burckhard, Ms. Mary O'Neill, and Mr. Kevin Dalsted together with JPL's Drs. Yunjin Kim, Mahta Moghaddam, Paul Siqueira, Paul Rosen, and Jeff Hilland. JPL's Synthetic Aperture Radar (SAR) activities were discussed and how 1 m SAR data could be used to map wind damage to crops, as well as soil moisture and biomass estimations from SAR. Drs. Kim, Moghaddam and Siqueira were interested in how Radar data might fit into South Dakota's proposed NASA EPSCoR work. Dr. Moghaddam spoke on several applications of SAR data and how she has used interferometry to infer vegetation height and Radar to estimate biomass and soil moisture. She is also interested in GIS and its role in data handling and analysis, which dovetails nicely with South Dakota's proposed projects. In discussing how they could work together, Dr. Kim indicated that, while they are interested in SD's proposed project, they have no funding to cover staff time and expenses. However, Dr. Kim indicated that they could host one or two graduate students through a SD funded activity. This would provide training for the students so that they could contribute to the overall project, particularly as it referred to Radar analyses. Dr. Kim showed interest in perhaps placing a Radar unit on a tower unit proposed in SD's project.

In June 2000, SDSM&T graduate student Patrick Kozak traveled to the Niobrara Valley Preserve to work with EROS Data Center (EDC) and NASA on calibration of Landsat 7 overpasses. Mr. Kozak will work with Dave Meyer and Bruce Wylie of EDC collecting spectra to help calibrate both the Landsat and AVIRIS calibrations and work on an ongoing project to use remote sensing to classify distinct vegetation species sponsored by NASA/DOI. Mr. Kozak will also work with Bruce Wylie on the possible use of decision trees for classification of imagery.

Dr. Daniel Swets of Augustana College attended the EPSCoR Expo in May 2000 at JSC. JSC personnel indicated an interest in working with university researchers in EPSCoR projects. NASA researchers involved with JSC's Regenerative Life Support project were very interested in looking at collaborative research arrangements regarding South Dakota's prairie wetlands project as a model for water/plant integration, and provided Dr. Swets with numerous contacts.

In April 2000, Dr. Dan Swets of Augustana College and Catherine Van Note, research assistant, attended the Council on Undergraduate Research's (CUR) fourth annual "Posters on the Hill" session. They met individually with Senators Tom Daschle and Tim Johnson and Representative John Thune of South Dakota, and with Senators Grams and Wellstone and Representative Sabo of Minnesota. Dr. Swets and Ms. Van Note personally met Daschle, Johnson, Thune, and Sabo, and with aids of Grams and Wellstone to extol the virtues of the NASA research programs. Ms. Van Note brilliantly told her story about how perhaps some things in NASA could change, but NASA's funding of research is invaluable, allowing her to engage in research that would otherwise have been impossible.

In April 2000, Dr. Ed Duke of SDSM&T and graduate student Patrick Kozak traveled to the USGS Spectroscopy Laboratory in Denver and met with Dr. Roger Clark,

one the best-known scientists among users of NASA's AVIRIS imaging spectrometer data. While there, they successfully ran the USGS Tetracorder algorithm for mapping mineral distributions in AVIRIS images of Pat Kozak's thesis area in Death Valley. Arrangements were made to install some of the USGS spectral processing routines on Unix workstations at SDSM&T in order to continue to use the applications developed at USGS. An exchange of mineral samples and laboratory spectra is planned with the USGS in order to enhance their on-line digital spectral library. Dr. Duke and Mr. Kozak expect to make future visits to the USGS Spectroscopy Laboratory for processing imagery related to research on metamorphic processes or research on the Black Hills and Prairie Pothole regions. Several months following this meeting, Dr. Duke presented "Delineation of Isograds and Reaction Fronts in Contact-Metamorphosed Siliceous Dolomite Using Remote Sensing and Field Spectroscopy" by Mr. Kozak at the Geological Society of America's annual convention in Reno, NV in November 2000.

In March 2000, SDSU's Kevin Dalsted attended the SAR Users Working Group (SUWG) Meeting in Washington, D.C. JPL's Steven Bard invited Mr. Dalsted to become a member of the SUWG as a representative of Precision Farming Users.

SDSM&T's Dr. Ed Duke, Pat Kozak, Dr. Maribeth Price, and Dr. Lee Vierling, and SDSU's Dr. Suzette Burckhard attended the AVIRIS Earth Science and Applications Workshop at JPL on February 23-25, 2000. The following paper was presented and published in the Workshop Proceedings: Duke, E.F., and Kozak, P.K., 2000, "Imaging spectrometry and metamorphic processes." The paper was well received and numerous contacts were made that could develop into important collaborations. In addition to the AVIRIS applications for geological work, collaborative discussion focused on investigating vegetation properties and changes, especially forests and wetlands, and for swelling clays, contaminated soils, and vegetation discrimination. Valuable discussions with Drs. Lee Vierling and Suzette Burckhard were held regarding cooperation on prairie wetland research and possible studies of abandoned mine lands in Montana. The SD researchers all learned a great deal about the state-of-the-art in remote sensing applications for ecosystem classification and analysis, which will be important as SD researchers begin to apply similar approaches to SD ecosystems.

Dr. Mary O'Neill and graduate student Michelle Kelly of SDSU traveled to Stennis Space Center in February 2000 to meet with Dr. Ramona Travis from the UAO and several people from contractor InDyne, Inc. Precision agriculture, wetlands, and transportation issues were identified as the application areas in which Stennis would have the greatest interest for SD EPSCoR collaboration.

In February 2000, Dr. Bradley Reed of EROS Data Center visited with Jim Compton Tucker of NASA-Goddard on behalf of the SD NASA-EPSCoR Consortium to further refine the cooperative efforts between the Augustana College-EDC team and the NASA team on the seasonality smoothing and metrics computations, analysis, and application. The meeting and follow-up from Dr. Daniel Swets, Augustana College, further reinforced the positive aspects of the collaborative relationship between the NASA team and the SD EPSCoR team, whereby the SD team could enhance the

productivity of the NASA-Goddard team by assisting with some of the work in the research projects.

In January 2000, SDSU's Dr. Dennis Helder, Dr. Suzette R. Burckhard, Dr. Vernon R. Schaefer, Dr. Dave Clay, Dr. Steve Schiller, Sung Shin, and Michelle Kelly traveled to Goddard Space Flight Center to meet with Goddard representatives on Precision Agriculture. The purpose of the meeting was to establish contact with NASA researchers at Goddard in the Earth & Space Data Computing Division, Biospheric Sciences Branch, and Hydrological Sciences Branch.

In January 2000, SDSU's Kevin Dalsted met with NASA staffers and scientists about LightSAR and potential uses of SAR in agriculture. He also attended the Jan. 19-20, 2000 workshop on NASA's plan for spaceborne SAR remote sensing.

In December 1999, SDSM&T's Dr. Andy Detwiler visited the Center for Interdisciplinary Remotely-Piloted Vehicle Studies (CIRPAS) with NASA's Tony Strawa. He then visited NASA Ames and met with Steve Weggener, Bob Chatfield, and Tony Strawa. Dr. Detwiler presented a seminar to the airborne science group on an exploratory instrument development project, the M-meter, in which he had participated with support from our armored aircraft facility operation. Discussion also included the use of Uninhabited Airborne Vehicles (UAV's) in airborne research.

In December 1999, Dr. Sharon Clay and Chuck Cole of SDSU traveled to Denver to attend Pecora 14 LandSatellite Information III Demonstrating the Value of Satellite Imagery conference. Cole presented a paper titled "Prediction of weed infestation levels through integration of landscape position, weed ecology and remote sensing" by Clay, S, Dalsted, K, Cole, C, et. al.

SDSU's Kevin Dalsted, Mary O'Neill, and Dr. David Clay and SDSM&T's Dr. Pat Zimmerman and Dr. Lee Vierling attended the UMAC-PARC Workshop "Climate Change: Meeting the Challenge/Seizing the Opportunities" in Grand Forks, ND in November 1999.

In November 1999, SDSU's graduate student Michelle Kelly attended the National Remote Sensing Applications Conference and Workshop Auburn, Alabama and later met with Jeff Luvall, Doug Rickman, Dale Quattrochi and Dr. Jim Dowdy at MSFC.

In November 1999, Dr. Bill Capehart of SDSM&T attended the Land Surface Hydrology Program Investigators Meeting, Columbia, MD and then visited GSFC. Dr. Capehart spoke with Bill Crosson and Bill Lapenta regarding possible collaborations in NASA EPSCoR, as well as with Mike Jasinski and Charron Birkett of NASA GSFC about potential wetland interests. While there, he also met with Marv Wesley of Argonne National Lab and Bill Gutowski and Mark Person of the University of Iowa and University of Minnesota, respectively. Similar work areas include surface-groundwater interactions and the use of Modflow. He also met with Glenn Liston. Dr. Capehart coordinated with Adam Schlosser, David Mocko, and Yogesh Sud to work on a GCIP-

LSA/NW project involving subgrid snow cover representations using Glen Liston's parameterizations and related land-air-surface & groundwater interactions. Methodologies for representing subgrid snow melt processes in the Simplified Simple Biosphere model (SSiB) and its ramifications on the aggregation of surface fluxes and groundwater were discussed in detail. Preliminary discussions were made to represent an SSiB run over the Prairie Coteau during the wet up period in the early 1990's. Both Sud and Mocko were very interested in the prairie wetland problem and in interaction with SD researchers on the problem in the context of global modeling once a strategy is fleshed out, as was the case with Marshal Space Flight Center. Dr. Capehart also met with Ted Engman, head of the Hydrology Branch to discuss details on SD's NASA-EPSCoR program.

Dr. Bradley Reed of EROS Data Center made a presentation in November 1999 to Dr. Compton "Jim" Tucker from Goddard regarding collaborative research work being done with Dr. Reed, James Rowland, and Dr. Larry Tieszen of EDC and Dr. Daniel Swets of Augustana College on the Seasonality project, involving NDVI smoothing techniques and seasonality metrics derived from the NDVI data. The software was released to the NASA group for their evaluation. The group then worked to tailor the algorithms to suit the particular needs of the NASA research group, working under the SD NASA-EPSCoR umbrella. Dr. Tucker helped identify a post doc / visiting professor that could be supported under a joint position with EDC and Augustana College to bolster the relationship between NASA, EDC, and the South Dakota NASA EPSCoR Consortium.

Dr. Maribeth Price and Dr. Lee Vierling of SDSM&T attended Goddard Space Flight Center Space Day in September 1999. In August 1999, Dr. Dan Swets of Augustana College and Dr. Bradley Reed and Jim Rowland from EROS Data Center established a working relationship with Dr. Compton "Jim" Tucker at NASA Goddard regarding the possibility of teaming Tucker's Seasonality research projects with the South Dakota NASA EPSCoR effort. Drs. Tucker and Swets exchanged e-mail over the potentials of pooling efforts under the SD NASA EPSCoR umbrella, which was met with a great deal of enthusiasm.

Conclusions

The foundation for the NASA-EPSCoR program in South Dakota is based on substantial planning, investments, and accomplishments by the State's three research universities during the past five years. Examples of these changes are: 1) A new priority on demonstrable competitiveness in scholarly activity and research is being employed to evaluate university faculty members, 2) Institutional policies and research offices have been established to promote and facilitate the procurement of external funding, 3) Competitive stipends and active recruiting programs has yielded an increase in SMET graduate student enrollment, 4) Instrumentation and facilities have been obtained with a combination of federal and state funding for state-of-the-art research in the targeted areas of biocomplexity, biogeochemistry, earth system science, materials science, nano-science & engineering, molecular & cellular biology, and agricultural science, 5) The Governor

of South Dakota by executive order has recently formed the Science & Technology Council (STC), whose membership comprises selected private business people, state agency representatives, legislators, Board of Regents members, and university administrators (including the PI of this NASA-EPSCoR proposal), 6) An enhanced interest in technology transfer and SBIR programs, and 7) The development of organizations such as the Western Research Alliance in Western SD and the Sioux Falls Research Alliance in Eastern SD. These two relatively new Alliances have been designed to provide a research forum to interface the university research communities with individuals from local economic development offices, investment groups, regional entrepreneurs, relevant state and local governmental agencies, etc. One of the founding members of the Western Research Alliance is the PI of this proposal. Further information on this WRA organization and its activities is available at <<http://w-research-alliance.org/>>.

According to the NSF analysis in 1985, South Dakota was deemed the "most eligible" state for inclusion in the EPSCoR program. Based on the same set of parameters, South Dakota has moved from its initial ranking of #19 in 1985 to a ranking of #14 in 2000 on this EPSCoR eligibility scale. Only one other state has improved its ranking to a greater degree than South Dakota during this fifteen-year time period. Further evidence of the change in the State's research environment comes from the National Science Foundation Data Brief of July 10, 2000. Here, South Dakota is shown to be one of only eight states with a statistically significant, real annual R&D growth rate of over 3% between 1987 and 1997. Another indicator of R&D growth is the 97% increase in externally-funded research awards obtained at the South Dakota School of Mines and Technology during the period from 1995 to 2000. It is upon this new research foundation that we propose to activate and build a successful, meritorious NASA-EPSCoR program in South Dakota!